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CERTIFICATION

I, the undersigned, Robert Ellenberger Shillenn, hereby certify that I am competent to translate texts from Italian into English. I also certify that I have translated the attached text completely and to the best of my ability. I furthermore acknowledge my liability for any willful fraud or gross negligence for any misrepresentation of the meaning of the original text.

Document: ***Italian document with English header***
"NUVERA FUEL CELLS EUROPE S.r.l."
Title: "DESCRIZIONE DI INVENZIONES INDUSTRIALE"
relating to a fuel cell

Date: May 14, 2008

Signature: Robert E. Shillenn

DESCRIPTION OF AN INDUSTRIAL INVENTION

In the name of NUVERA FUEL CELLS EUROPE S.r.l.

The present invention relates to a membrane electrochemical generator with direct injection of liquid water into the gaseous reagents.

In technology there are known processes for converting chemical energy into electrical energy, based on membrane electrochemical generators.

In general, a membrane electrochemical generator is made up of a several reactions cells connected to one another in electrical series and assembled according to a bipolar configuration.

Each reaction cell converts the chemical energy generated during the reaction of a fuel with a combustion supporting substance without degrading it completely to the state of thermal emergency, and thereby it is not subject to the limitations of the Carnot cycle. More specifically, the fuel is fed into the anode chamber of the reaction cell and is comprised, for example, of a gaseous mixture rich in hydrogen or a solution of light alcohols, such as methanol or ethanol, while the combustion supporting substance is fed into the cathode chamber of the cell itself and is comprised, for example, of air or oxygen. The fuel is electron oxidized catalytically in the anode chamber releasing H^+ protons and electrons, which are consumed in the cathode chamber through an electron reducing catalytic reaction of the combustion supporting substance, with the production of water. A proton exchange membrane, which separates the anode chamber and the cathode chamber, allows for a the continuous flow of the H^+ protons from the anode chamber to the cathode chamber, while at the same time preventing the passage of the

electrons and which, instead, takes place by way of an outside electrical circuit. In this way, the difference in electrical potential that is created at the heads of the reaction cell is at a maximum.

The proton exchange membrane commonly used in membrane electrochemical generators are comprised of a chemically inert polymer, partially functionalized with groups capable of undergoing, in the presence of liquid water, acid-base hydrolysis with a resulting separation of electrical charge. More precisely, the hydrolysis in question consists in the release of positive ions (cations) in the formation of fixed negative charges on the polymer.

In order to keep the proton exchange membranes constantly hydrated so as to make the hydrolysis occur and thereby the separation of electrical charge that allows for proton conduction, the gaseous reagents (fuel and combustion supporting substance) are fed into the electrochemical generator saturated with water vapor and at a temperature close to that of the reaction cells by means of costly and complex saturation devices, placed outside the electrochemical generator itself.

The known electrochemical generators are also equipped with suitable cooling devices that ensure the removal of the heat produced during the functioning of the generator itself, through heat exchange with a circulating fluid (for example, de-ionized water). The heat must be efficiently removed from the electrochemical generator itself, not only on account of the limited thermal stability of proton exchange membranes, which are usually unsuitable for operating at temperatures higher than 100°C, but also to

prevent, as much as possible, the evaporation of the water produced during the electron reduction reagent and its resulting removal by the flow of inert [substances][1] and unconverted reagents exiting the generator, with a consequent possibility of drying out the membrane.

However, the presence of such cooling devices makes the known electrochemical generators even more complex and costly.

A known solution for getting around these drawbacks is described in international patent application WO 00/63992 of the same applicant, which provides for direct injection of a calibrated flow of liquid water into a membrane electrochemical generator comprised of reaction cells that have a reticulated materials, of the type described in US patent 5.482.792, placed inside the anode and cathode chambers. The calibrated flow of liquid water, by partially evaporating inside the reticulated material, taking advantage of the elevated surface development, provides at the same time for the humidification of the gaseous reagents and for maintaining the constant temperature of the electrochemical generator without using two distinct devices, thereby limiting the costs and the complexity of the generator itself.

The known solution described above, while being advantageous in various ways, still presents some drawbacks.

In particular, the injection of the calibrated flow of liquid water takes place peripherally to the active area of each reaction cell and transversally to the flow of the gaseous reagents. This modality of injecting the liquid water, because of the reduced quantity of motion of the water and because of phenomena of adhesion to the walls of the gaskets, may cause an uneven distribution of the water inside the active area of

[1] *Translator's note:* Words that appear in brackets in this translation reflect words that do not appear in the original, but have been inferred from grammar and context and have been added to enhance readability.

each cell, with the resulting formation of areas that are not watered, hot and in danger of dehydration. This has the effect of causing the drying of the membranes, thereby lessening their useful life and furthermore discouraging the evaporative mechanism of the water, with a resulting increase in the flow rate of the liquid water necessary to maintain the constant temperature of the electrochemical generator.

The object of the present invention is to design an electrochemical generator that will be without the drawbacks described.

According to the present invention, a membrane electrochemical generator has been designed, as defined in claim 1.

To enhance understanding of the invention, an embodiment thereof will now be described, as a non-limiting example and with reference to the attached drawings, in which:

- figure 1 shows a blown up side view of a first embodiment of a membrane electrochemical generator according to the invention;

- figure 2 shows a front view of one component of the electrochemical generator in figure 1;

- figures 3a, 3b and 3c show front views of a second embodiment of the electrochemical generator in figure 1;

- figure 4 shows a blown up side view of a membrane electrochemical generator according to the invention;

- figures 5a and 5b show front views of two different embodiments of one component of the electrochemical generator in figure 4;

- figure 6 shows a side view of one portion of a third embodiment of a membrane electrochemical generator according to the invention;

- figures 7a and 7b show front views of a component of the electrochemical generator in figure 6;

- figures 8a and 8b show front views of a further component of the electrochemical generator in figure 6;

- figures 9a and 9b show front views of a different design of the component shown in figures 8a and 8b;

- figures 10a and 10b illustrate front views of a different design of the component shown in figures 7a and 7b;

- figures 11a and 11b illustrate front views of a different design of the component shown in figures 8a and 8b; and

- figures 12a and 12b illustrate front views of a different design of the component shown in figures 9a and 9b.

Figure 1 shows a first embodiment of a membrane electrochemical generator according to the invention. Electrochemical generator 1 comprises a plurality of reaction cells 2, which are connected to one another in series and assembled according to a filter-press type configuration.

More in detail, each reaction cell 2 is limited by a pair of conductive bipolar plates 3, with flat surfaces, between which there are, moving from the inside out, proton exchange membrane 4; a pair of porous electrodes 5; a pair of catalytic layers 6 deposited at the interface between membrane 4 and each one of porous electrodes 5; a

pair of current collectors/distributors 7, designed by means of a reticulated metallic element described in US patent 5.482.792, which electrically connect the conductive bipolar plates 3 to porous electrodes 5 and at the same time distribute the gaseous reagents; a pair of gaskets 8a and 8b, formed by an anode gasket 8a and cathode gasket 8b. Anode gasket 8a is intended to seal the periphery of anode chamber 9 from reaction cell 2 in order to prevent the escape of fuel (particularly hydrogen), while cathode gasket 8b is intended to seal the periphery of cathode chamber 10 from reaction cell 2 in order to prevent the escape of the combustion supporting substance (particularly air). Anode and cathode gaskets 8a and 8b are also intended to embody the seat of current collectors/distributors 7.

As shown in figure 2, conductive bipolar plates 3 have a substantially rectangular shape and each exhibit external portion 10 equipped with: first and second upper openings 12 and 13 for the passage of the gaseous reagents, the fuel and the combustion supporting substance respectively); first and second lower openings 14 and 15 for the discharge of the reaction produced mixed with any residual reagents; lateral openings 16 for the passage of a cooling fluid, particularly liquid water. External portion 11 is also equipped with a plurality of holes 17 to accommodate the straps whereby the closing of electrochemical generator 1 is carried out.

During the assembly of electrochemical generator 1, the joining between the first and second upper openings 12 and 13 of all the conductive bipolar plates 3 causes the

formation of two upper longitudinal conduits 18, while the joining between the first and the second lower openings 15 and 15 of all the conductive bipolar plates 3 causes the formation of two lower longitudinal conduits 19. Both upper longitudinal conduits 18, of which only one is shown in figure 1, define the conduits for the feeding of the gaseous reagents, while the two lower longitudinal conduits 19, only one of which is shown in figure 1, define the conduits for the discharge of the reaction products mixed with any residual reagents. Alternatively, lower longitudinal conduits 19 may be used as feeding conduits, and upper longitudinal conduits 19 can be used as discharge conduits. It is also possible to feed one of the two gaseous reagents through one of upper longitudinal conduits 18, using the corresponding lower longitudinal conduit 19 for the discharge and to feed the other gaseous reagent through the other lower longitudinal conduit 19, while the corresponding upper longitudinal conduit 18 for the discharge.

Moreover, the connection between lateral openings 16 of all the conductive bipolar plates 3 causes the formation of lateral conduits, not shown in figure, for the passage of the liquid water.

Each conductive bipolar plate 3 is also equipped with a plurality of calibrated fluid injection holes 20, all having the same diameter (for example, between 0.2 mm and 1 mm), through which the liquid water that flows in the lateral conduits of electrochemical generator 1 is injected inside reaction cells 2, as will be better explained below.

Calibrated fluid injection holes 20 are aligned with one another in order to ensure an equal distribution of the liquid water and are placed between the first and second upper openings 12 and 13.

As shown in figures 3a, 3b and 3b, anode and cathode gaskets 8a and 8b of each reaction cell 2 are substantially rectangular in shape and they present respective first and second upper openings $8a_1$, $8b_1$ and $8b_2$ for the passage of the gaseous reagents; respective first and second lower openings $8a_3$, $8a_4$, $8b_3$ and $8b_4$, for the discharge of the reaction products mixed with any residual reagents; respective lateral openings $8a_5$ and $8b_5$ for the passage of the liquid water.

In greater detail, first upper openings $8a_1$ (through which the fuel passes) and second lower openings 8a4 of anode gasket 8a are connected to anode chamber 9 by means of distribution channels 21a and discharge channels 21b respectively, extracted in the thickness of anode gasket itself (figure 3a). In turn, second upper openings $8b_2$ (through which the combustion supporting substance passes) and first lower openings $8b_3$ of cathode gasket 8b are connected to cathode chamber 10 by means of distribution channels 23a and discharge channels 23b respectively, extracted in the thickness of anode gasket itself (figure 3b). Distribution and discharge channels 21a, 21b, 23a and 23b have a comb structure that allows them to uniformly distribute and collect, within each reaction cell 2, the gaseous reagents and the reaction products, with the latter being mixed with any residual reagents. Anode gasket 8a is also equipped with fluid

collection channels connected with lateral openings $8a_5$. Optionally fluid collection channels 22 may also be connected to distribution channels 21a (figure 3c).

In filter-press configuration, first and second upper openings $8a_1$, $8a_2$, $8b_1$ and $8b_2$ of anode and cathode gaskets 8a and 8b, in union with first and second upper openings 12 and 13 of conductive bipolar plates 3, form both upper longitudinal conduits 18; first and second lower openings $8a_3$, $8a_4$, $8b_3$ and $8b_4$ of anode and cathode gaskets 8a and 8b, in union with first and second lower openings 14 and 15 of conductive bipolar plates 3, form both lower longitudinal conduits 19; lateral openings $8a_5$ and $8b_5$ of anode and cathode gaskets 8a and 8b, in union with lateral openings 16 of conductive bipolar plates 3, form the lateral feed conduits of the liquid water.

Moreover, in filter-press configuration, fluid collection channels 22, with which anode gasket 8a is equipped, are located in correspondence with calibrated fluid injection holes 20, which, in turn, are each located in correspondence with distribution channel 23a of cathode gasket 8b.

Anode and cathode gaskets 8a and 8b are also equipped with a plurality of holes 24 to accommodate the straps whereby the closing of electrochemical generator 1 is carried out.

In turn, electrochemical generator 1 is bounded by two conductive terminal plates 25 (figure 1), one of which is equipped with outlets, not shown in figure 1, for the hydraulic connection of upper and lower longitudinal conduits 18 and 19 and of the lateral conduits. Moreover, both conductive terminal plates 25 are equipped with suitable holes (also not shown in figure 1) to accommodate the straps.

Operationally, the flow of liquid water fed through the lateral conduits of electrochemical generator 1 flows fluid collection channels 22 of anode gaskets 8a and, from here, through calibrated fluid injection holes 20, it is injected into the cathode reactive flows entering into adjacent reaction cells 2.

Alternatively, if anode gaskets 8a have a structure the same as the one shown in figure 3b and cathode gaskets 8b have a structure the same as the one shown in figure 3a, the flow of liquid water flows into fluid collection channels 22, this time inserted in cathode gaskets 8b, and from here, through calibrated fluid injection holes 20, it is injected into the anode reactive flows entering into adjacent reaction cells 2.

In both cases, the maintenance of the temperature of electrochemical generator 1 and the humidification of membrane 4 are carried out through the evaporation of the flow of liquid water through the reticulated metallic element that constitutes current collector/distributor 7.

In figure 4, in which parts the same as the ones already illustrated in reference to figures 1, 2 and 3, have been provided with the same reference numbers, there is shown a second embodiment of a membrane electrochemical generator according to the invention. Electrochemical generator 100 is completely similar to electrochemical generator 1 except for the fact that it includes a plurality of additional cells 101, interposed among reaction cells 2 in a 1:1 ratio.

With reference to figure 62, additional cells 101 are essentially rectangular in shape and have dimensions equal to those of reaction cells 2 and each one includes an external portion 102a, which functions as a separation surface for the two gaseous reagents and a hollow central portion 102b to embody the seat of current collector/distributor 7. External portion 102a is equipped with first and second upper openings $103a_1$ and $103a_2$, first and second lower openings $103b_1$ and $103b_2$ and lateral openings 104 placed in correspondence with first and second upper openings $103a_1$ and $103a_2$.

In filter-press configuration, f first and second upper openings $103a_1$ and $103a_2$ of additional cells 101, in union with first and second upper openings $8a_1$, $8a_2$, $8b_1$ and $8b_2$ of anode and cathode gaskets 8a and 8b, which, in this case, have all the same structure and the same as the one shown in figure 3b, and with first and second upper openings 12 and 13 of conductive bipolar plates 3, form the two upper longitudinal conduits 18; first and second lower openings $103b_1$ and $103b_2$ of additional cells 101, in union with first and second lower openings $8a_3$, $8a_4$, $8b_3$ and $8b_4$ of anode and cathode gaskets 8a and 8b and with first and second lower openings 14 and 15 of conductive bipolar plates 3, form the lower longitudinal conduits 19. In turn, lateral openings 104 of additional cells 101, in union with 8a5 and 8b5 anode and cathode gaskets 8a and 8b and with lateral openings 16 of conductive bipolar plates 3, form the lateral conduits to feed the liquid water. The external portion 102a is also equipped with a plurality of holes 105 to accommodate the straps.

Moreover, on both the faces of external portion 102a, there is present a fluid collection channel 106 connected to lateral openings 104 and placed beneath first and second upper openings $103a_1$ and $103a_2$. In filter-press configuration, fluid collection channel 106 is in correspondence to calibrated fluid injection holes 20 of conductive bipolar plates 3.

Operationally, the flow of liquid water fed through the lateral conduits of electrochemical generator 100 flows into fluid collection channel 106 and, from here, through calibrated fluid injection holes 20, is injected into the reactive flows entering into adjacent reaction cells 2.

Alternatively, fluid collection channel 106 may be formed by two lateral portions 107 and 108, connected with lateral openings 104, with the latter being made in correspondence with first and second lower openings $103b_1$ and $103b_2$ (figure 5b).

In this case, the flow of liquid water, before reaching calibrated fluid injection holes 20 and [before] being injected into reaction cells 2, enters into the two lateral portions 107 and 108 of fluid collection channel 106, and then cross over the entire surface of current collector/distributor 7 of additional cell 101, becoming reheated in countercurrent or equicurrent with respect to at least one of the reactive flows entering into reaction cells 2. In this way, additional cells 101 operate as cooling cells of electrochemical generator 100.

Figure 6 shows a cross-section of a third embodiment according to the invention of a membrane electrochemical generator. Electrochemical generator 200, only a portion of which is shown in figure 6, is formed by a plurality of reactor cells 201 and additional cells 202, which are connected to one another in series and assembled according to a filter-press type configuration; each additional cell 202 is interposed between a pair of reaction cells 201.

In greater detail, each reaction cell 201 is limited by a pair of conductive bipolar plates 203 with flat surfaces, between which there are comprised, moving from inside out, proton exchange membrane 204; a pair of porous electrodes 205; a pair of current collectors/distributors 203, which electrically connect conductive bipolar plates 203 to porous electrodes 205; a pair of gaskets 207 intended to seal the periphery of reaction cell 201 in order to prevent the escape of the reagent gases.

Conductive bipolar plates 203, shown in figures 7a and 7b, are essentially rectangular in shape and have a thickness equal to 0.1 + 0.4 mm. They present an external section 208 equipped with first and second upper openings $208a_1$ and $208a_2$, with first and second lower openings $208b_1$ and $208b_2$ and lateral openings 209. External portion 208 is also equipped with a plurality of holes 210 to accommodate the straps whereby the closing of electrochemical generator 200 is carried out.

During the assembly of electrochemical generator 200, the connection between first and second upper openings $208a_1$ and $208a_2$ of all conductive bipolar plates 203 causes the formation of two upper longitudinal conduits 211, while the connection between first and second lower openings 208b1 and 208b2 of all conductive bipolar plates 203 causes the formation of two lower longitudinal conduits 212. Both upper longitudinal conduits 211, only one of which is shown in figure 6, define the feed conduits of the gaseous reagents (fuel and combustion supporting substance), while both lower longitudinal conduits 212, only one of which is shown in figure 6, define the discharge conduits of the reaction products mixed with any residual reagents. Alternatively, lower longitudinal conduits 212 may be used as feed conduits, and upper longitudinal conduits 211 as discharge conduits. It is also possible to feed one of the two gaseous reagents through one of the upper longitudinal conduits 211, while using the corresponding lower longitudinal conduit 212 for the discharge and to feed the other gaseous reagent through the other lower longitudinal conduits 212, while using the corresponding upper longitudinal conduits 211 for the discharge.

Moreover, the connection among lateral openings 209 of all conductive bipolar plates 203 causes the formation of lateral conduits, not shown in figure 6, for the passage of the liquid water.

As shown in figure 7b, gaskets 207 are attached onto a single surface of each conductive bipolar plate 203 by means of pressing (injection or compression),

mechanical anchoring or gluing. These embody the seat of current collectors/distributors 206 in addition to bounding the active area of reaction cells 201.

In particular, gaskets 207 are made of a soft material, for example silicone, elastomer, etc., and exhibit a final thickness that may vary from a few tenths of a millimeter to a few millimeters.

Each conductive bipolar plate 203 is also equipped with a plurality of upper calibrated holes 213 and with a plurality of lower calibrated holes with a diameter comprised between 0.1 mm and 5 mm. It is through the plurality of upper calibrated holes 213a that the gaseous reagents coming from adjacent additional cell 202 flow, while it is through the plurality of lower calibrated holes 213 that the reaction products and the residual reagents flow from reaction cell 201, as will be explained in greater detail below. Upper calibrated holes 213a are aligned with one another for the purpose of ensuring an even distribution of the gaseous reagents and are placed underneath first and second upper openings $208a_1$ and $208a_2$. In turn, lower calibrated holes 213 are aligned with one another and placed above first and second lower openings $208b_1$ and $208b_2$. Both upper 213a and lower 213b calibrated holes are placed at a distance from gasket 207 equal to approximately 1 mm in order to take best advantage of the active area of reaction cell 201.

Moreover, each conductive bipolar plate 203 is equipped with a plurality of calibrated fluid injection holes 230, all having the same diameter (for example, comprised between 0.2 mm and 1 mm), through which the liquid water that originates

from adjacent additional cell 203 is injected into reaction cell 201. Calibrated fluid injection holes 230 are aligned with one another in order to ensure even distribution of the liquid water and are placed underneath upper calibrated holes 213a.

Now making reference to figures 8a and 8b, each additional cell 202 is essentially rectangular in shape and has dimensions equal to those of reaction cell 201. Every additional cell 202 comprises a rigid external portion, made of plastic or metal, which functions as a separation surface for the two gaseous reagents and a central hollow portion 202b to embody the seat of current collector/distributor 206. Rigid external portion 202a is equipped with first and second upper openings $214a_1$ and $214a_2$, first and second lower openings $214b_1$ and $214b_2$ and lateral openings 215. In filter-press configuration, first and second upper openings $214a_1$ and $214a_2$ of additional cells 202, in union with first and second upper openings $208a_1$ and $208a_2$ of conductive bipolar plates 203, form the upper longitudinal conduits 211, while first and second lower openings $214b_1$ and $214b_2$ of additional cells 202, in union with first and second lower openings $208b_1$ and $208b_2$ of conductive bipolar plates 203, form the two lower longitudinal conduits 212. In turn, lateral opening 215 of additional cells 202, in union with lateral cells 209 of conductive bipolar plates 203, form the conduits for the feed of the liquid water. Rigid external portion 202a is also equipped with a plurality of holes 216 to accommodate the straps.

Moreover, each additional cell 202 comprises gaskets 217, which are attached on both surfaces of rigid external portion 202a, so as to define on each surface of the external surface itself: gaseous reagent collection channel 218a, placed underneath first

and second upper openings $214a_1$ and $214a_2$; collection channel 218b for reaction products and residual reagents, placed above first and second lower openings $214b_1$ and $214b_2$; feed channel 219 to connect one of the two upper openings $214a_1$ and $214a_2$ to the collection channel for gaseous reagents 218a; discharge channel 220 to connect collection channel 218b for reaction products and residual reagents to one of lower openings $214b_1$ and $214b_2$; a fluid collection channel 221 placed above reagent gas collection channel 218a and connecting lateral openings 209. In filter-press configuration, gas reagent collection 218a is located in correspondence with lower calibrated 213a; collection channel 218b for reaction products and residual reagents is located in correspondence with lower calibrated holes 213b, while fluid collection channel 221 is located in correspondence with calibrated fluid injection holes 230. Gaskets 217 seal gaseous reagent collection channel 218a; collection channel 218b for the reaction products and residual reagents and fluid collection channel 221, so as to prevent the passage of the gaseous reagents, the reaction products and the residual reagents and the liquid water into additional cell 202.

Moreover, gaskets 217 are made of a soft material (silicone, elastomer etc.) compatible with the closing/assembly loads imposed by gaskets 207 of reaction cell 201

and are attached to rigid external portion 202a by means of pressing (injection or compression), mechanical anchoring or gluing.

Electrochemical generator 200 operates as follows. The gaseous reagents (fuel and combustion supporting substance) that are fed into electrochemical generator 200 through upper longitudinal channels 211 flow into the gaseous reagent collection channels 218a through feed channels 219. From here, the gaseous reagents, since they cannot flow into additional cells 202, since gaseous reagent collection channels 218a are sealed by means of gaskets 217, pass through the plurality of upper calibrated holes 213a attached on conductive bipolar plates 203 of adjacent reaction cells 201. In this way, the gaseous reagents reach the active area of reaction cells 201 where the actual reaction itself takes place.

In turn, the reaction products and the residual reagents produced in reaction cells 201 pass through the plurality of lower calibrated holes 213b located on conductive bipolar plates 203 of the reaction cells themselves, reaching discharge product collection cells 218b of adjacent additional cells 202. From here, through discharge channels 220 they flow from electrochemical generator 200.

Moreover, according to the present invention, the flow of liquid water fed through the lateral conduits of electrochemical generator 200 flows into fluid collection channels 221 and, from here, through calibrated fluid injection holes 230, is injected into the reactive flows entering into adjacent reaction cells 201, providing for the humidification of membrane 204 and for maintaining the temperature of electrochemical generator 200.

As an alternative to fluid collection channel 221, additional cell 202 may comprise two fluid collection lateral channels (222, 223) connected to lateral openings 215 and placed above discharge product collection channel 218b (figures 9a and 9b).

In this case, the flow of liquid water, before reaching calibrated fluid injection holes 230 and [before] being injected into reaction cells 201, enters through the two fluid collection lateral channels 222 and 223 and then it cross over the entire surface of current collector/distributor 206 of additional cell 202, becoming reheated in countercurrent or equicurrent with respect to at least one of the reactive flows entering into reaction cells 201. In this way, additional cells 202 operate like cooling cells of electrochemical generator 200.

Moreover, as shown in figures 10a and 10b, calibrated fluid injection holes 230 of each conductive bipolar plate 203 can be placed above (instead of underneath) upper calibrated holes 213a. In this case, fluid collection channel 221 is placed above gaseous reagent collection channel 218a (figures 11a and 11b).

As an alternative, in addition to fluid collection channel 221, additional cell 202 may comprise a first and a second lateral channel 224 and 225, placed above discharge product collection channel 218b, and a third and a fourth lateral channel 226 and 227, placed beneath gaseous reagent collection channel 218a (figures 12a and 12b).

In this case, the flow of liquid water, before reaching calibrated fluid injection holes 230 and [before] being injected into reaction cells 201, enters into first and second lateral channel 224 and 225 and exits from the third and the fourth lateral channel 226

and 227, crossing current collector/distributor 2006 of additional cell 202 in such a way as to become reheated in countercurrent or in equicurrent with respect to at least one of the reactive flows fed into reaction cells 201.

The advantages that can be attained with the electrochemical generators described are the following.

In the first place, calibrated fluid injection holes 20 and 230 make it possible to obtain an even distribution of the calibrated flow of liquid water inside reaction cells 2 and 201. In this way, the cooling of electrochemical generators 1, 100 and 200, as well as the hydration of proton exchange membranes 4 and 204 are more even, with the effect of increasing the useful life of the membranes themselves, in addition to encouraging the evaporative mechanism of the liquid water, thus reducing the rate of flow necessary to maintain the temperature of the generators themselves.

Moreover, the pre-heating of the flow of liquid water realized by using the additional cells shown in figures 5b, 9a, 9b, 12a and 12b, amplifies the advantages described above, because it mainly encourages the evaporative mechanism of the liquid water, making it possible to subsequently reduce the time for reaching the stationary conditions for the start of electrochemical generators 1, 100 and 200.

Finally, it is evident that modifications and variants can be applied to the electrochemical generators described, without leaving the scope of the present invention.

CLAIMS

1. Membrane electrochemical generator (1, 100, 200) fed with gaseous reagents and comprising a plurality of reaction cells (2, 201) connected to one another in series, with each reaction cell (2, 201) being bounded by conductive bipolar plates (3, 203), between where there is comprised proton exchange membrane (4, 204), characterized in that said conductive bipolar plates (3, 203) comprise a plurality of calibrated fluid injection holes (20, 230) for the injection of a calibrated flow of a cooling fluid into reaction cells (2, 201).

2. Generator according to claim 1, characterized in that each of said reaction cells (2, 201) is form by an anode chamber (9) and by a cathode chamber (10) separated from said membrane (4, 204); said anode chamber (9) and said cathode chamber (10) each comprise an electrically conductive reticulated element (7, 206) inside which said calibrated flow of said cooling fluid partially evaporates while at the same time providing for the humidification of said gaseous reagents and to the maintenance of the temperature of said membrane electrochemical generator (1, 100, 200).

3. Generator according to claim 1 or 2, characterized in that said calibrated fluid injection holes (20, 230) are aligned to one another and placed in correspondence with feeding openings (12, 13, 208a, $208a_2$) for the feeding of said cooling fluid, said feeding

openings (12, 13, 208a, $208a_2$) and said lateral openings (11, 208) being located in external portion (11, 208) of said conductive bipolar plates (3, 203).

4. Generator according to any one of claims 1 – 3, characterized in that said calibrated fluid injection holes (20, 230) all have the same diameter and comprised between 0.2 mm and 1 mm.

5. Generator according to any one of the previous claims, characterized in that said conductive bipolar plates (3) are interposed between a pair of gaskets (8a, 8b) of two adjacent reaction cells (2); each of said gaskets (8a, 8b) embody a seat for a respective electrically conductive reticulated element (7) and comprising:

- respective feeding openings ($8a_1$, $8a_2$, $8b_1$, $8b_2$) for the passage of the gaseous reagents;
- respective lateral openings ($8a_5$, $8b_5$) for the passage of said cooling fluid;
- respective distribution channels (21a, 23a) to connect said respective feeding openings ($8a_1$, $8a_2$, $8b_1$, $8b_2$) to said respective electrically conductive reticulated element (7).

6. Generator according to claim 5, characterized in that at least one of said gaskets (8a, 8b) comprises respective fluid collection channels (22) connected to said respective lateral openings ($8a_5$, $8b_5$), said fluid collection channels (22) being interposed between said feeding openings ($8a_1$, $8a_2$, $8b_1$, $8b_2$) and said distribution channels (21a, 23a) and being suitable for collecting said cooling fluid.

7. Generator according to claim 5, characterized in that at least one of said gaskets (8a, 8b) comprises respective fluid collection channels (22) connected to said respective lateral openings ($8a_5$, $8b_5$) and to said respective distribution channels (21a, 23a), said respective fluid collection channels (22) being interposed between respective feeding openings ($8a_1$, $8a_2$, $8b_1$, $8b_2$) and said respective distribution channels (21a, 23a) and being suitable for collecting said cooling fluid.

8. Generator according to claim 6 or 7, characterized in that, in filter-press configuration, said fluid collection channels (22), present on at least one of gaskets (8a, 8b) are superimposed over said calibrated fluid injection holes (20) and that said calibrated fluid injection holes (20) are located in correspondence with one distribution channel (21a, 23a) located on the other gasket (8a, 8b).

9. Generator according to any one of claims 1 – 4, characterized in that it comprises a plurality of additional cells (101), each additional cell (101) being interposed between a pair of reaction cells (2), embodying a seat for respective electrically conductive reticulated element (7) and comprising external portion (102a), in which are located:

- lateral openings (104) for the passage of said cooling fluid;
- at least one fluid collection channel (106) connected to said lateral openings (104) and suitable for collecting said cooling fluid;

- feeding openings ($103a_1$, $103a_2$) for the passage of said gaseous reagents;
- discharge openings ($103b_1$, $103b_2$) for the discharge of reaction products and residual reagents.

10. Generator according to claim 9, characterized in that said fluid collection channel (106) is placed underneath said feeding openings ($103a_1$, $103a_2$).

11. Generator according to claim 9 or 10, characterized in that, filter-press configuration, said fluid collection channel (106) is superimposed over said calibrated fluid injection holes (2)) of said conductive bipolar plates (3).

12. Generator according to claim 9, characterized in that said fluid collection channel (106) is formed by a first and a second lateral portion (107, 108) placed above said discharge openings ($103b_1$, $103b_2$).

13. Generator according to claim 12, characterized in that said cooling fluid, before reaching said fluid injection holes (20) crosses over the entire surface of said respective electrically conductive reticulated element (7), becoming reheated in countercurrent or in equi-current, with respect to at least one gaseous flow entering into said reaction cells (2).

14. Generator according to any one of claims 1 – 4, characterized in that said conductive bipolar plates (203) comprise a plurality of first calibrated holes (213a) for the passage of said gaseous reagents and a plurality of second calibrated holes (213b) for

the discharge of reaction products and any residual reagents and that said plurality of calibrated fluid injection holes (230) are placed in correspondence with said plurality of first calibrated holes (213a).

15. Generator according to claim 14, characterized in that said first calibrated holes (213a) are aligned with one another and placed in correspondence with said feeding openings ($203a_1$, $203a_2$) of said conductive bipolar plates (203) and that said second calibrated holes (213b) are aligned with one another and placed in correspondence with discharge openings ($203b_1$, $203b_2$) placed on said external portion (208) of said conductive bipolar plates (203).

16. Generator according to claim 14 or 15, characterized in that said reaction cells (201) comprise gasket (207) covering a single surface of said external portion (208) of said conductive bipolar plates (203), said gasket (207) embodying a seat for a respective electrically conductive reticulated element (206).

17. Generator according to any one of claims 14 – 16, characterized in that it comprises a plurality of additional cells (202), [with] each additional cell (202) being interposed between a pair of reaction cells (201) and comprising rigid external portion (202a) and hollow central portion (202b), said rigid external portion (202a) functioning as a separation surface for the gaseous reagents and said hollow central portion (202b) embodying a seat for respective electrically conductive reticulated element (206),.

18. Generator according to claim 17, characterized in that said rigid external portion (202a) is equipped with feeding openings ($214a_1$, $214a_2$) for the feeding of said gaseous reagents, with discharge openings ($214b_1$, $214b_2$) for the discharge of the reaction products and the residual reagents and with lateral openings (215) for the passage of said cooling fluid.

19. Generator according to claim 17 or 18, characterized in that said rigid external portion (202a) is covered in each surface with gasket (217), [with] said gasket (217) defining on each surface of said rigid external portion (202a) a collection zone for the gaseous reagents (218a) placed in correspondence with said feeding openings ($214a_1$, $214a_2$) of said rigid external portion (202a), a zone for collection of the reaction products and the residual reagents (218b) placed in correspondence with said discharge openings ($214b_1$, $214b_2$) of said rigid external portion (202a), feeding channel (219) to connect one of said feeding openings ($214a_1$, $214a_2$) to said collection zone for the reagent gases (218a), a discharge channel (220) to connect said collection zone for the reaction products and the residual reagents (218b) to one of said discharge openings ($214b_1$, $214b_2$).

20. Generator according to claim 19, characterized in that said gasket (117) seals said collection zone for the gaseous reagents (218a) and said collection zone for the reaction products and the residual reagents (218b) in such a way to prevent the

passage of said gaseous reagents and of reaction products and any residual reagents inside said additional cell (202).

21. Generator according to claim 19 or 20, characterized in that, in filter-press configuration, said collection zone for the gaseous reagents (218a) is superimposed over said first calibrated holes (213a) and said collection zone for the reaction products and the residual reagents (218b) is superimposed over said second calibrated holes (213b).

22. Generator according to any one of claims 19 – 21, characterized in that said calibrated fluid injection holes (230) are placed underneath first calibrated holes (213a) and that said gasket (217) defines, on each surface of said rigid external portion (202a), fluid collection channel (221) placed underneath said feeding openings ($214a_1$, $214a_2$) of said additional cells (202).

23. Generator according to any one of claims 19 – 21, characterized in that said calibrated fluid injection holes (230) are interposed between said feeding openings ($208a_1$, $208a_2$) of said bipolar places (203) and said first calibrated holes (113a, 113b) and that said gasket (217) defines, on each surface of said rigid external portion (202a), fluid collection channel (221) interposed between said discharge openings ($214b_1$, $214b_2$) of said additional cell (202) and said collection zone of the gaseous reagents (118a).

24. Generator according to claim 22 or 23, characterized in that, in filter-press configuration, said fluid collection channel (221) is superimposed on said calibrated fluid injection holes (230).

25. Generator according to any one of claims 19 – 21, characterized in that said additional cells (202) comprise a first and a second lateral fluid collection channel (222, 223) connected to said lateral openings (215) of said additional cells (202) and placed above said discharge openings ($214b_1$, $214b_2$) of said additional cells (202) and that said cooling fluid, before reaching said fluid injection holes (230) passes through said first and second lateral fluid collection channel (222, 223) and then crosses over the entire surface of said electrically conductive reticulated element (206), becoming pre-heated in countercurrent or in equicurrent with respect to at least one gaseous flow entering into said reaction cells (201).

26. Generator according to any one of claims 19 – 21, characterized in that said additional cells (202) comprise:

- a first and a second lateral fluid collection channel (224, 225) connected to said lateral openings (215) of said additional cells (202) and placed above said discharge openings ($214b_1$, $214b_2$) of said additional cells (202);

- a third and a fourth lateral fluid collection channel (226, 227) connected to said lateral openings (215) of said additional cells (202) and placed underneath said feeding openings ($214a_1$, $214a_2$) of said additional cells.

- fluid collection channel (221) interposed between said feeding openings ($214a_1$, $214a_2$) of said additional cells (202) and said collection zone for the gaseous reagents (218a) and connected to said lateral openings (215) of said additional cells (202);

and that said cooling fluid, before reaching said fluid injection holes (230), enters through said first and second lateral fluid collection channel (224, 225) and then crosses over the entire surface of said respective electrically conductive reticulated element (206), becoming pre-heated in countercurrent or in equicurrent with respect to at least one gaseous flow entering into said reaction cells (201), while said cooling fluid then exits from said third or fourth lateral fluid collection channel (226, 227);

and that, in filter-press configuration, said fluid collection channel (221) is superimposed over said calibrated fluid injection holes (230).

27. Generator according to any one of the previous claims, characterized in that said cooling fluid is liquid water.

28. Membrane electrochemical generator, substantially as described with reference to the attached figures.

NUVERA FULL CELLS EUROPE S.r.l.

{Signature}

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